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Artificial Intelligence Project---RLE and MIT Computation Center
Memo 43--

Proposal for a General Learning Machine

by Bert Raphael

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Introduction

This memo proposes the development of a computer system which is capable of learning certain facts about arbitrary subject matter with an arbitrary vocabulary. It is believed by most researchers in this field that some sort of general learning machine is essential for the ultimate solution of the "Artificial Intelligence Problem." I believe that the system described below, which will be programmed to construct internal models based on the concepts indicated by the syntactic structure of the input text (but not on the specific subject area), will constitute a significant step toward such a machine.

Objects of the Research

1. To construct a working model of a basic type of general learning machine.
2. To discover where the principal obstacles in this area of research lie and how this machine can best be expanded, improved, and further generalized.

Background

Extensive research has been carried on by linguists on the syntax of English language (e.g. the SYNTHEX project at SDC, Dr. Oettenger's work at Harvard). Semantic models have been used in various computer problem-solving schemes (Gelernter's geometry machine, Lindsay's SAD-SAM). Several approaches to forms of computer learning have been made (Samuel's checker program, Rosenblatt's Perceptron, Feigenbaum's EPAM). Many programs which can prove some theorems in formal logic exist in the literature. I believe that all of these areas--syntax, semantics, learning, and logical deduction--must be exploited in the development of

future information retrieval and other "intelligent machine" systems. The following is a proposal for a marriage of all these disciplines, at a very elementary level, in a specific computer program. Natural English language is made the vehicle for man-machine communication in order to permit easy feed-back to the programmer of information about the state of the system, so that he can make modifications which will gradually improve the performance of the various inter-related components of the over-all system.

Structure of the System

Input to the system will consist of simple English declarative, imperative, and interrogative sentences. These inputs will be recognized as requests to create, modify, add to, or extract data from one or more internal "models." The result will be to change some internal representations or to output some information from the computer (in the form of English words). The work will largely be based on the following two assumptions:

1. Many concepts (e.g. set inclusion, part-whole relationships, and spacial relations), which are essential for the understanding of most elementary discourse, can be represented in the computer in certain standard ways using list structures (e. g. nouns may be associated with "description lists" which assign values to properties such as "subset of," "contains as parts," "is on top of," etc.). In order to search these structures and retrieve stored information it is sufficient to know something about the nature of the concept involved without being familiar with the subject matter.

2. In simple English the concepts involved are uniquely determined by the syntactic form of the sentences and certain key "function" words (prepositions, auxiliary verbs, etc.); and this determination may be made in a large number of cases without

becoming very involved with the intricacies of modern linguistics and grammatical classification.

In summary, the system will be prepared to deal with a certain set of elementary concepts. It will be programmed to identify relevant concepts from the syntactic form of the input sentences; make appropriate references or changes to its models for those concepts; and retrieve information (including logical consequences) from those models. The specific subject matter and vocabulary used will depend solely upon the sentences fed to the completed program when it is in operation.

Example

The following is a hypothetical dialogue between a human (H) and a version of the above computer system (C) which is prepared to handle the concepts of set-inclusion, part-whole relationships, number, and some spacial relations. C, in its initial state, has no vocabulary or knowledge other than its basic programs and the necessary related words, i.e. "a," "an", "is," "has," "on," "part of," "between," "next to," "one," "two," etc.

H: A boy is a person.
A man is a person.
Johnny is a boy.
A person has a head, a body, two arms, and two legs.
A dog has a head, a body, a tail, and four legs.
Spot is a dog.
A hand is part an arm.
A hand has five fingers.
What is Johnny?

C: A boy.

H: More generally, what is Johnny?

C: A person.

H: Does Johnny have a tail?

C: No.

H: A nose is part of a head.
Does Johnny have a nose?
C: Yes.
H: A quadrilateral is a polygon.
A triangle is a polygon.
A quadrilateral has four sides.
A square is a quadrilateral.
Is a square a polygon?
C: Yes.
H: How many sides does a square have?
C: Four.
H: How many sides does a trapezoid have?
C: ??
H: A trapezoid is a quadrilateral.
How many sides does a trapezoid have?
C: Four.
H: A book is on the table between the telephone and the lamp.
What is next to the lamp?
C: A book.
H: What is under the telephone?
C: The table.
H: Move the lamp off the table.
What is on the table?
C: A book and a telephone.

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